Imaging of skull lesions

The usual and unusual

43rd ESNR Annual meeting

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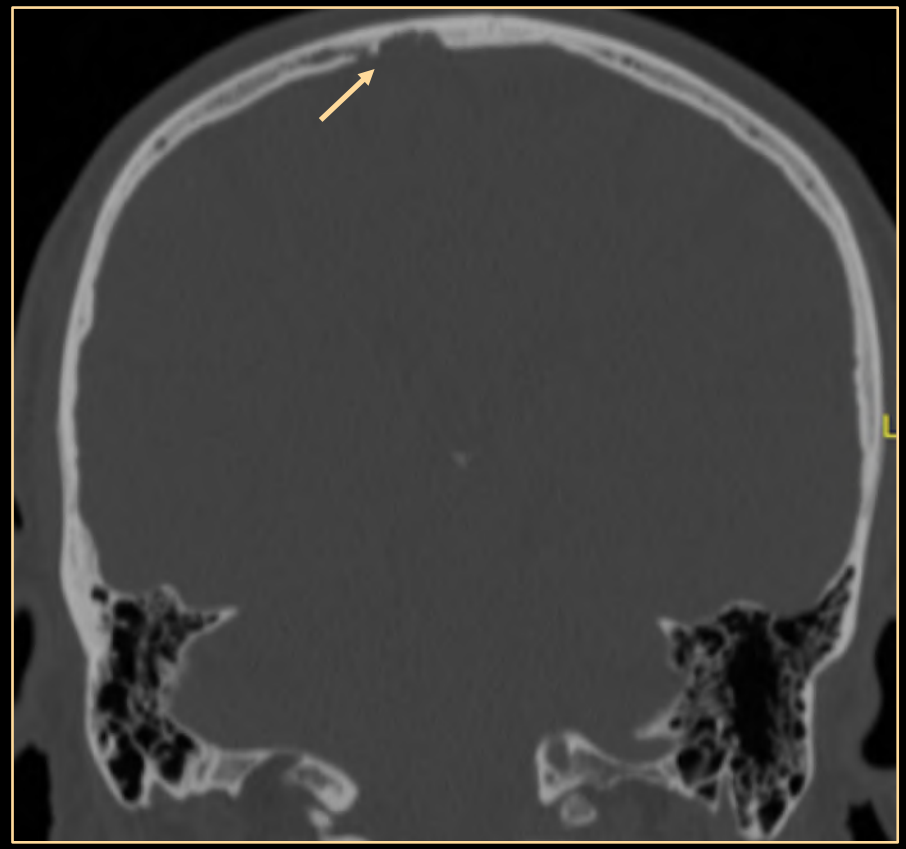
Content

- Pseudolesions
- Usual calvarial lesions: Sclerotic ⇔ Lytic
- Unusual calvarial lesions: Sclerotic ⇔ Lytic
- Take home messages

PART 1: The Usual and Unusual Pseudolesions

- **Arachnoid Granulations**
- Cerebrospinal fluid protrusions
- Subarachnoid space ➔ Venous sinus
- Very common / M = F
- DDx: Venous lakes
  - ➔ Venous protrusions in bone
  - ➔ enhancement! ⇔ AG
- Location
  1. Transverse sinus
  2. Superior sagittal sinus



An osteolytic focus (arrow) in the inner table near the superior sagittal sinus is a typical presentation of an arachnoid granulation.

PART 1: The Usual and Unusual Pseudolesions

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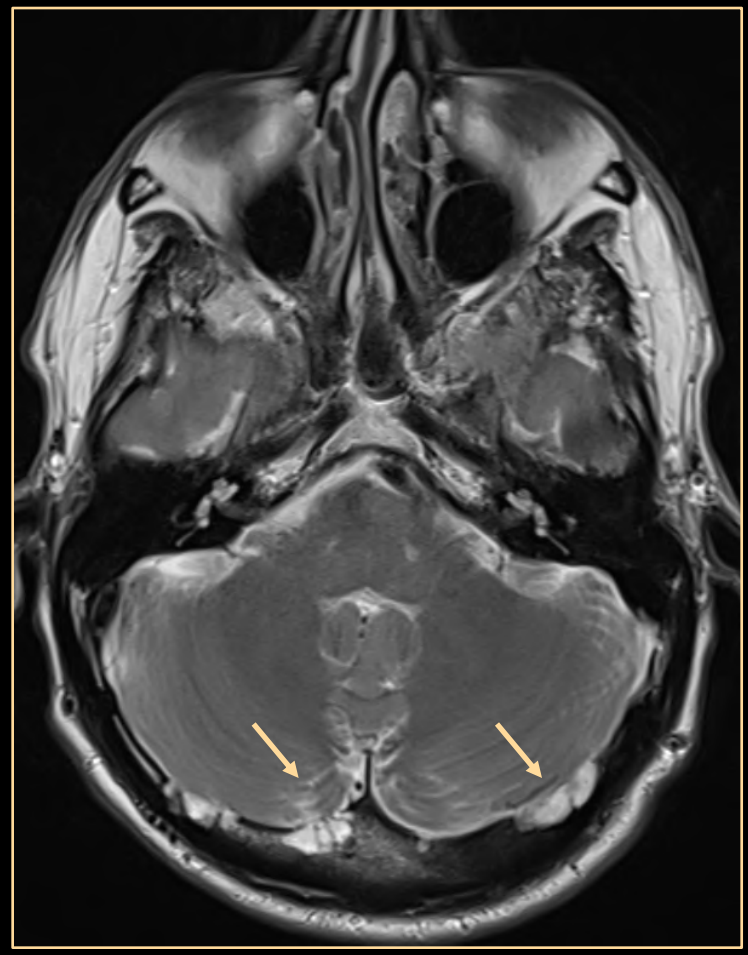
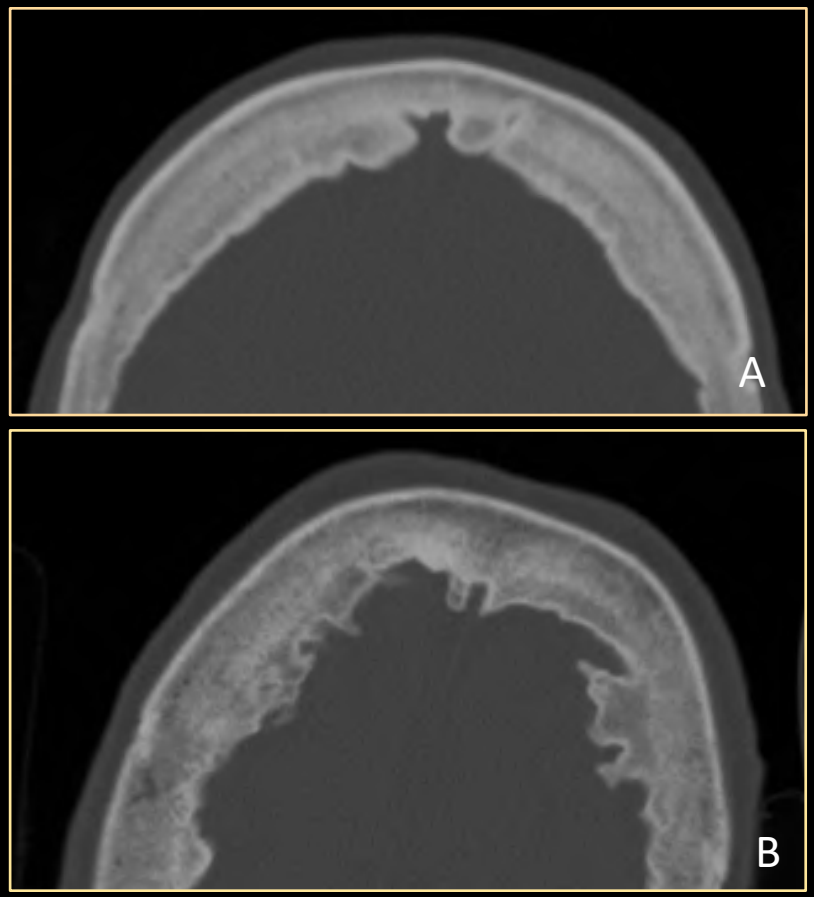


Multiple arachnoid granulations (arrows) in the internal table of the occipital bone.

PART 1: The Usual and Unusual Pseudolesions

- **Hyperostosis frontalis interna**
- New bone forming at internal table
- 5-12% in general population
- Etiology unknown
- Common in postmenopauzal women



Although mostly bifrontal with smooth borders (A),
Hyperostosis Frontalis Interna can present as sharp and irregular (B).

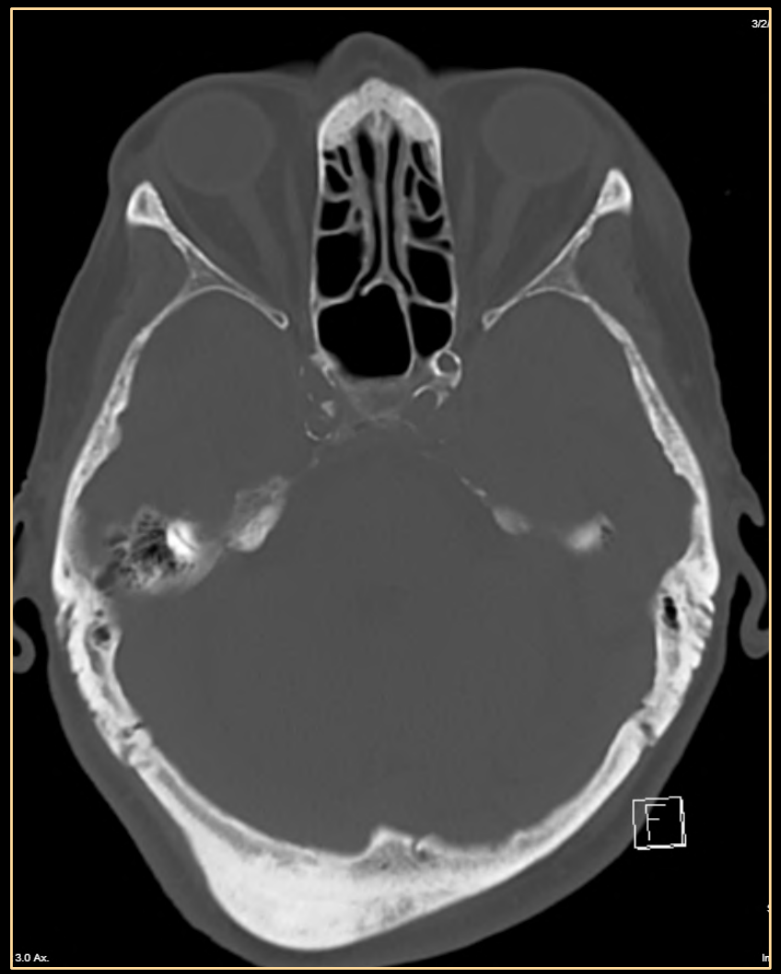
PART 1: The Usual and Unusual Pseudolesions

- Parietal foramina
- Congenital
- Thinning of diploe
- Non-progressive
- Unusual: 1 in 50.000
- DDx: Bilateral parietal thinning
  Acquired, mainly due to osteoporosis

Two round holes paired symmetrically in the parietal bones (arrows).

PART 2: The Usual Sclerotic calvarial lesions

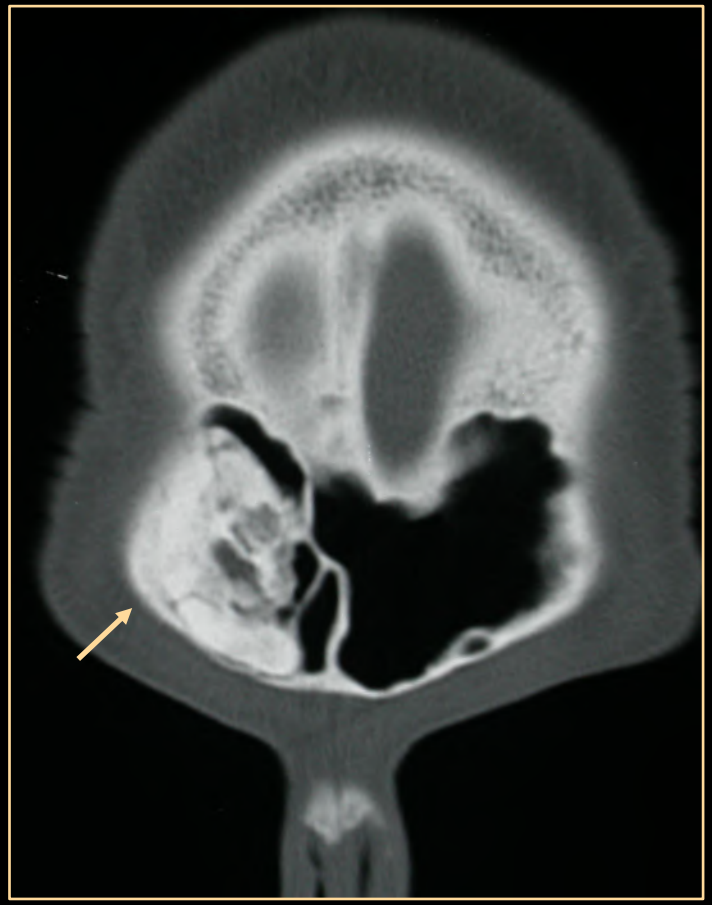
- Osteoma
- Well defined, pedunculated or nodular bone lesion
- Female > male
- Location
  - ✓external table
  - ✓frontal > temporal > occipital bone
  - ✓sinuses
- Imaging
  - CT: Well-delineated focal area of sclerosis at the external table
  - MRI: Low T1- and variable T2-signal



Typical osteoma morphology composed of compact bone, seamlessly blending in with the external table.

PART 2: The Usual Sclerotic calvarial lesions

- Osteoma
- Well defined, pedunculated or nodular bone lesion
- Female > male
- Location
  - ✓external table
  - ✓frontal > temporal > occipital bone
  - ✓sinuses
- Imaging
  - CT: Sclerotic lesion at the sinuses
  - MRI: Low T1- and variable T2-signal



Typical osteoma localisation in the frontal sinus.

PART 2: The Usual Sclerotic calvarial lesions

- Osteoma
- Well defined, pedunculated or nodular bone lesion
- Female > male
- Location
  - ✓external table
  - ✓frontal or temporal bone
  - ✓Sinuses
- Gardner syndrome
  - Multiple osteomas
  - Gastro-intestinal polyps
  - Soft tissue tumors

Multiple osteomas scattered around the calvarium in a patient with Gardner syndrome.

PART 2: The Usual Sclerotic calvarial lesions

- Fibrous Dysplasia
- Expanding fibrous tissue in bone
- Age: 75% < 30-years old
- Painless facial asymmetry
- Location: rib > skull > mandible
  - Monostotic FD (80%): Skull in 20% involved
  - Polyostotic FD (20%): Skull in 50% involved
  - Asymmetric
  - Orbital & paranasal sinus
  - Sphenoid bone

Typical presentation of FD with a ground glass matrix, located in the periorbital and perisinusal region.

PART 2: The Usual Sclerotic calvarial lesions

- Fibrous Dysplasia
- Plain film: expansile bone lesion
- CT: different imaging patterns
  - **Ground glass**
  - Sclerotic
  - Cystic areas
- MRI: Variable
  - Sclerotic = T1- and T2-hypointense
  - Cystic = T2-hyperintense
  - Enhancement = subtle to vivid

Typical presentation of FD with a ground glass matrix, located at the periorbital andd perisinusal region.

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FD can present as a heterogeneous lesion with cortical expansion and sclerotic foci (arrows) on a groundglass or fibrous background.

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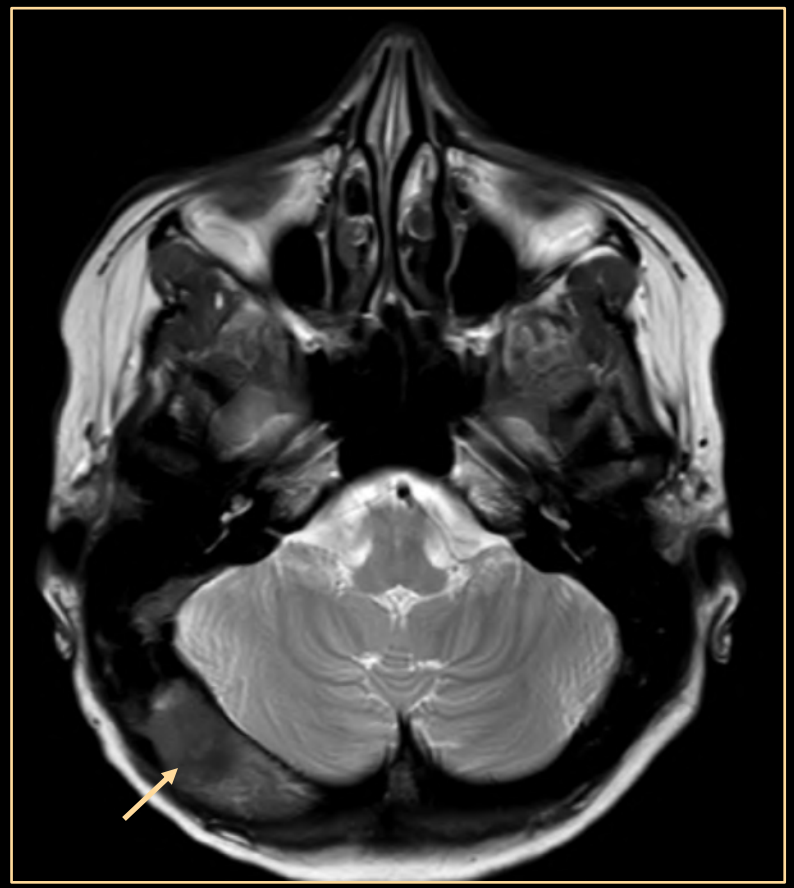

T2 Weighted image shows an expansile bony lesion with mixed signal due to fibrous and cystic components.

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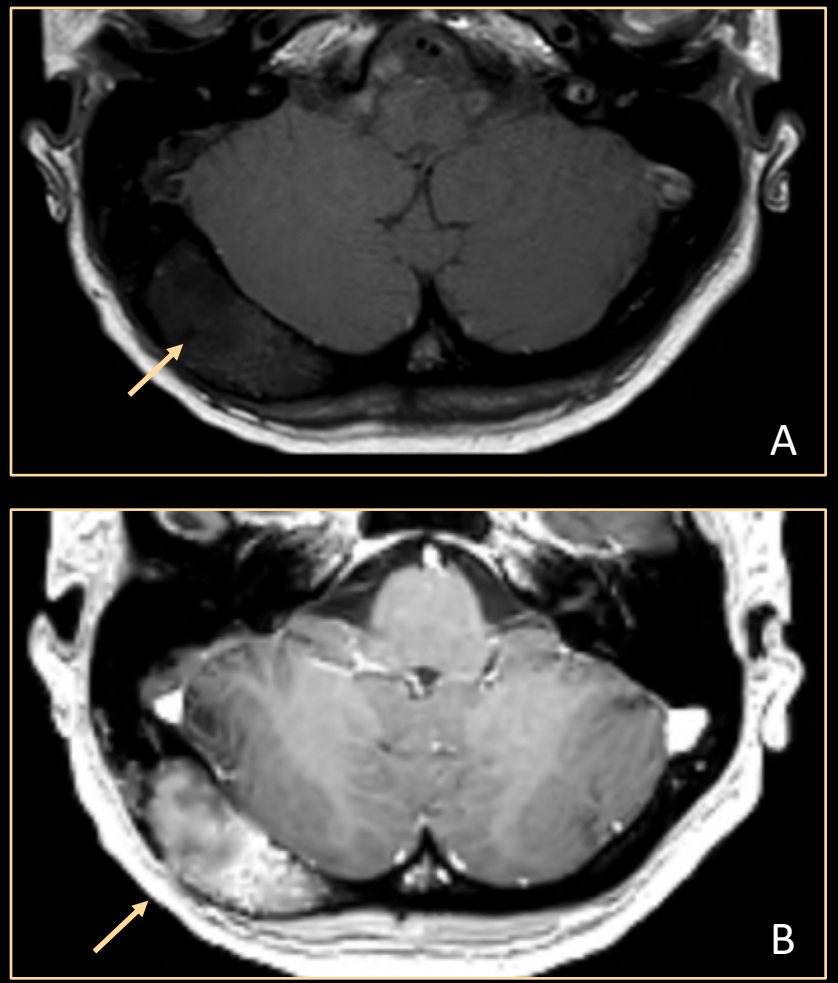
  - Enhancement = subtle to vivid
    ➔ MRI may cause more confusion!
    ➔ When in doubt, CT correlation mandatory



T1 WI before (A) and after (B) Gd administration:
FD (arrows) may enhance vividly and mimic a malignant lesion.

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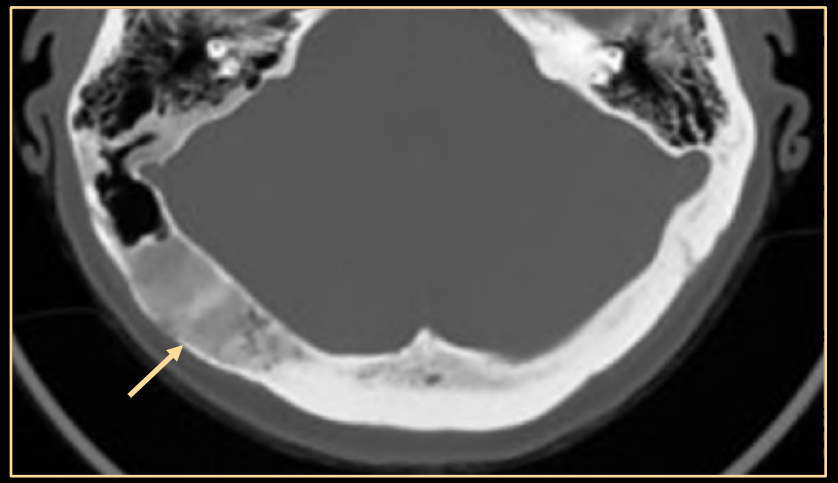
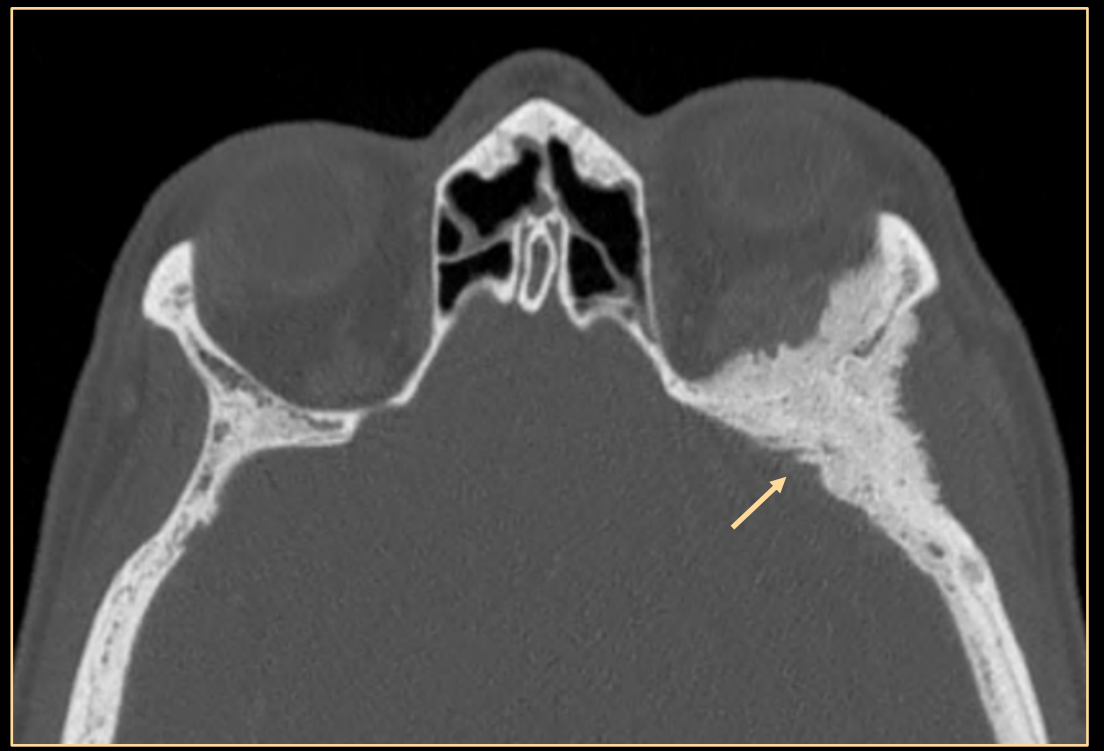


CT correlation shows a typical groundglass bone pattern in keeping with Fibrous Dysplasia.

PART 2: The Usual Sclerotic calvarial lesions

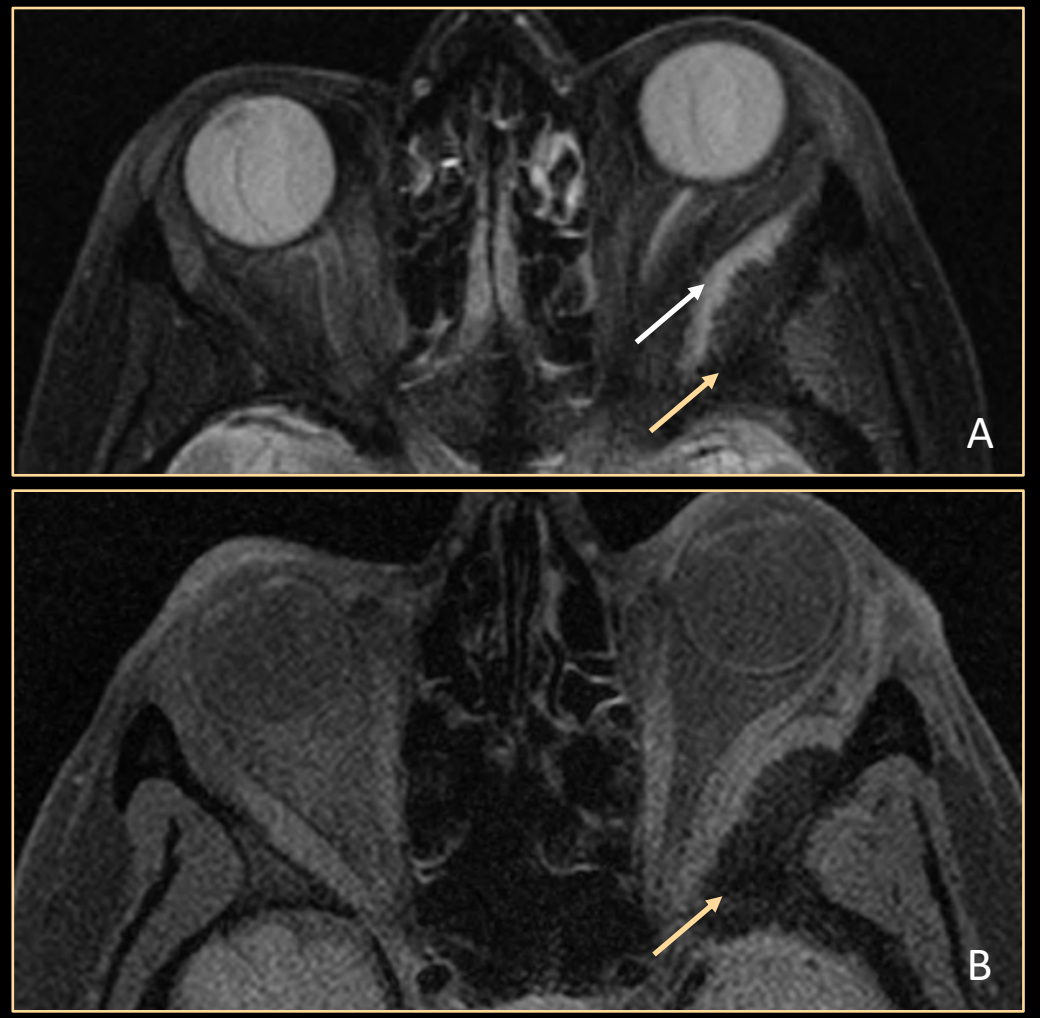
- Meningioma-en-plaque (MEP)
- Consists of proliferating meningeal cells
- 2% of all meningiomas
- Location: fronto-zygomatic sutures
- Symptoms
  - ophtalmoplegia
  - proptosis
  - headache
- Imaging
  - CT: hyperostotic / spiculated bone



A patient presented with left sided exophthalmos. CT shows a sclerotic lesion at the left greater sphenoid wing with spiculated borders.

PART 2: The Usual Sclerotic calvarial lesions

- Meningioma-en-plaque (MEP)
- Proliferating meningeal cells
- 2% of all meningiomas
- Location: fronto-zygomatic sutures
- Imaging:
  - MRI: intra-osseous:
    ➔T1-/T2-hypo
    extra-osseous:
    ➔T1-isointense to muscle
    ➔T2-hyperintense
  - Gd+ : dural enhancement



The signal of the intra-osseous component is low on both T1- and T2-WI (arrows in A and B), but shows an extra-osseous component with high T2 (arrow in A).

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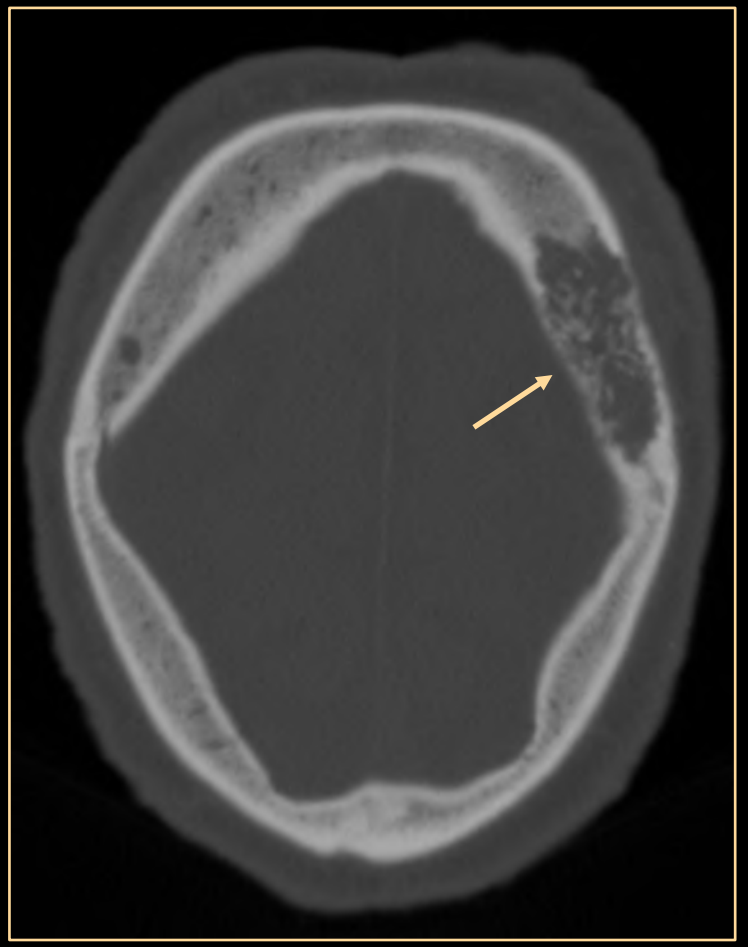
T1-WI image after contrast inection: The extra-osseous component shows peripheral enancement and continuity with the dura (arrow) of the left fossa media.

PART 2: The Usual Lytic calvarial lesions

- Intra-osseous *hemangioma**
- Slow growing venous malformation
- Age: fifth decade (M:V = 3:2)
- 10% of benign skull lesions
- Location: spine > calvarium
- Imaging
  - Plain film: sunburst sign
  - CT: intradiploic lytic lesion with radiating trabecular thickening

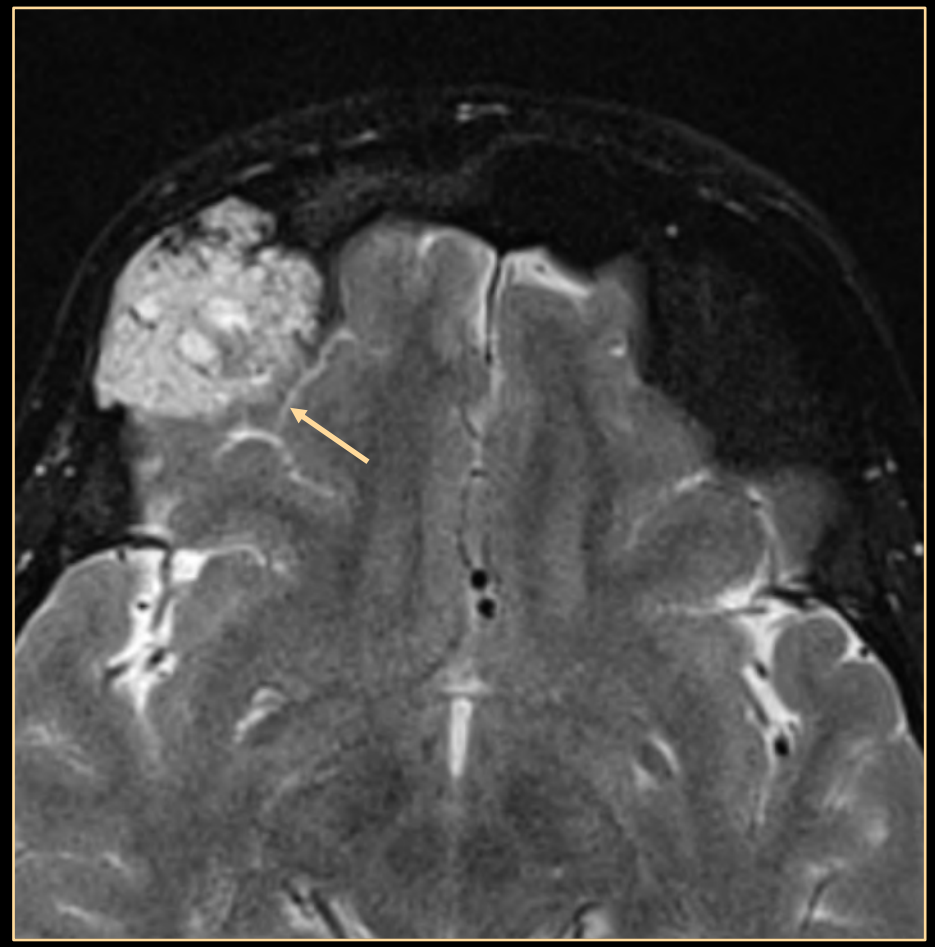


A lytic lesion (arrow) interspersed with trabeculae depicting the septations in between the vascular channels, with a typical spoke wheel appearance.

*A *hemangioma* is a misnomer for this entity and venous malformation is the preferred term.

PART 2: The Usual Lytic calvarial lesions

- Intra-osseous *hemangioma*
- Slow growing venous malformation
- Age: fifth decade (M:V = 3:2)
- 10% of benign skull lesions
- Location: spine > calvarium
- MRI
  - T1: iso- to hyperintense
  - T2: hyperintense = ‘bunch of grapes’
  - Gd+: diffuse enhancement



T2-weighted image shows a venous malformation in the frontal bone with markedly high signal due to the vascular tissue.

PART 2: The Usual Lytic calvarial lesions

- Intra-osseous *hemangioma*
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- Age: fifth decade (M/V = 3:2)
- 10% of benign skull lesions
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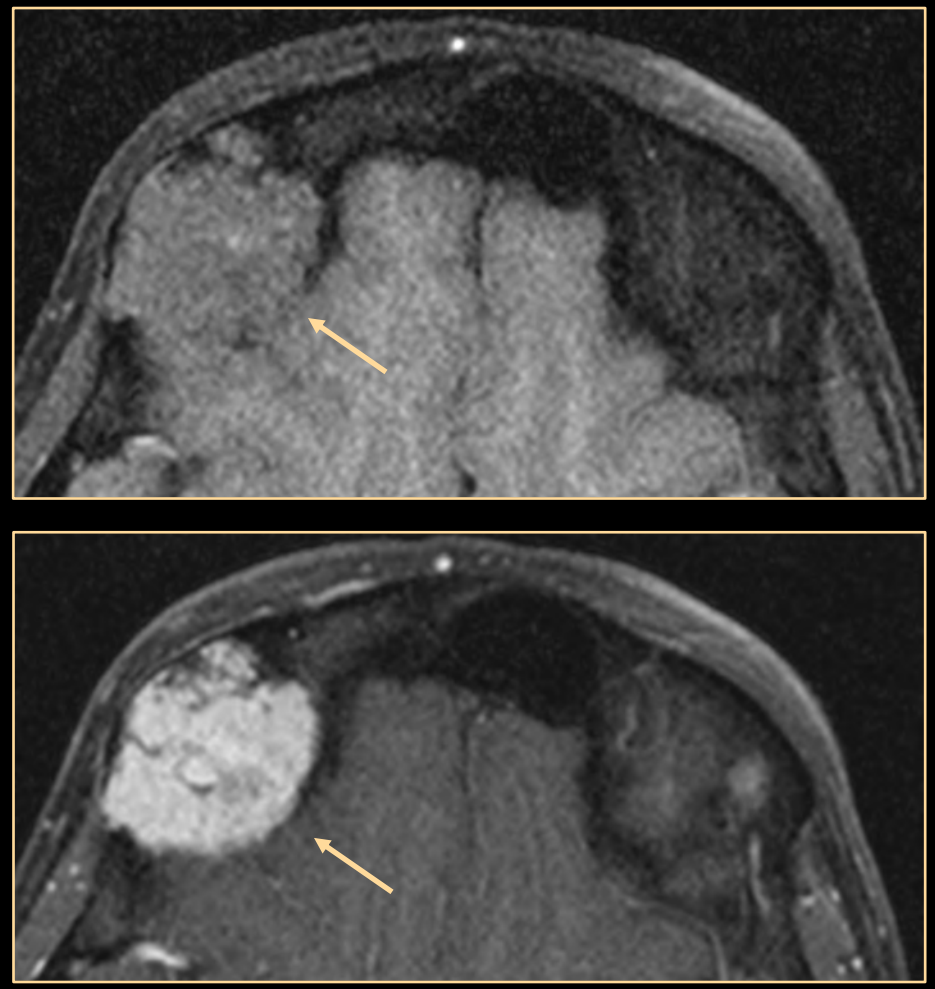
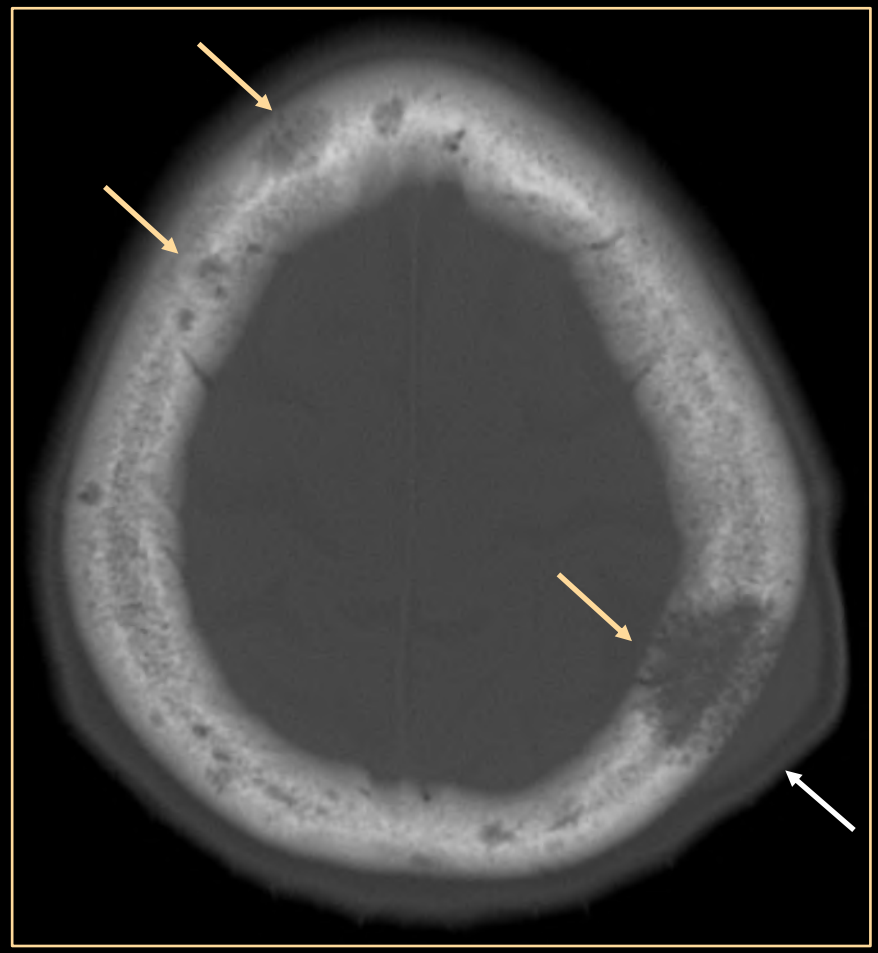


Fat suppressed T1-WI shows the venous malformation (arrow) is isointense to brain parenchyma and enhances vividly after contrast injection.

PART 2: The Usual Lytic Calvarial lesions

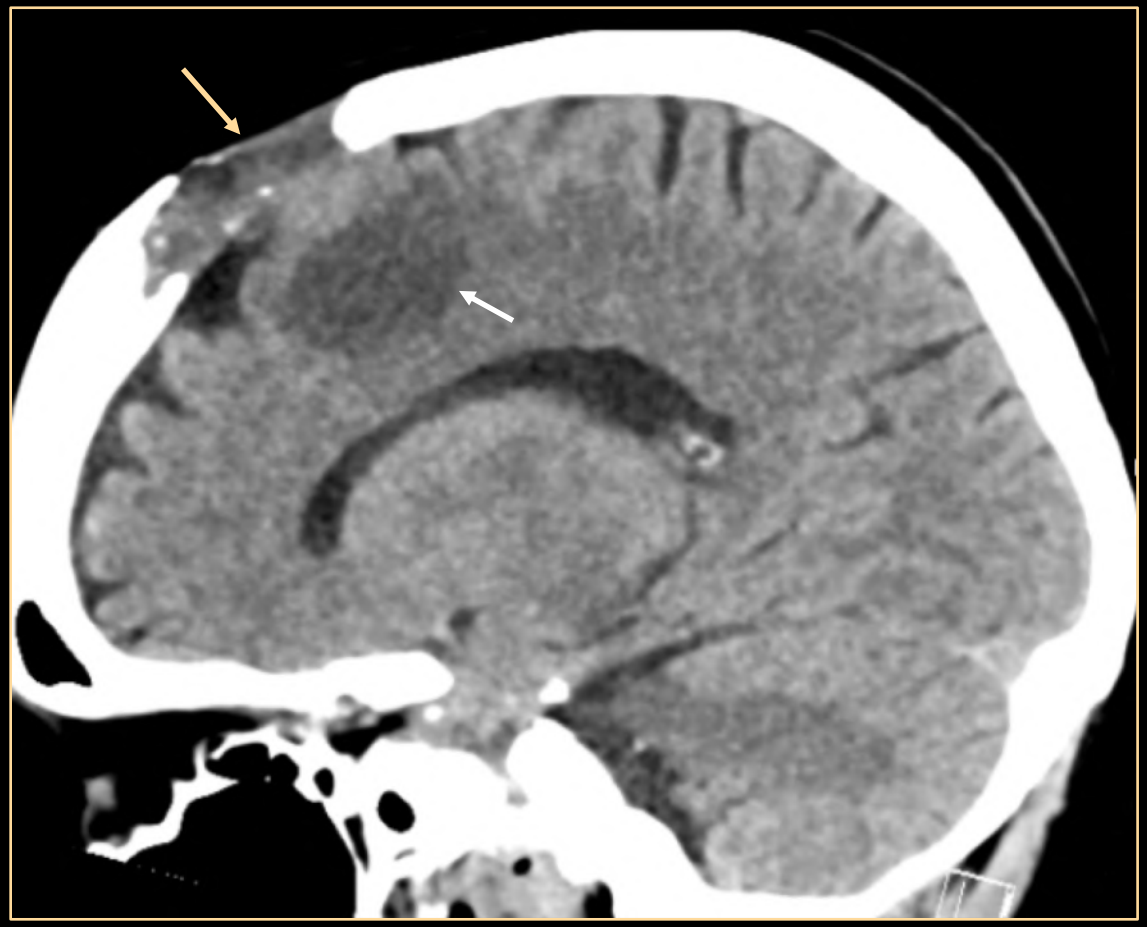
- Multiple Myeloma (*Kahler)*
- Proliferation of plasmacells in bone
- Most common bone (marrow) tumor
- Age: 5-8th decade
- Imaging
  - Plain film: punched out lesions
  - CT: multiple lytic foci
  - MRI: T1 hypointense T2: hyperintense
  - Enhancement: homo-/ heterogenous; Ring



Multiple lytic lesions in the in the calvarium (arrows). In the left parietal bone a lesion shows an extra-osseous soft tissue extension (arrow).

PART 2: The Usual **Lytic** Calvarial lesions

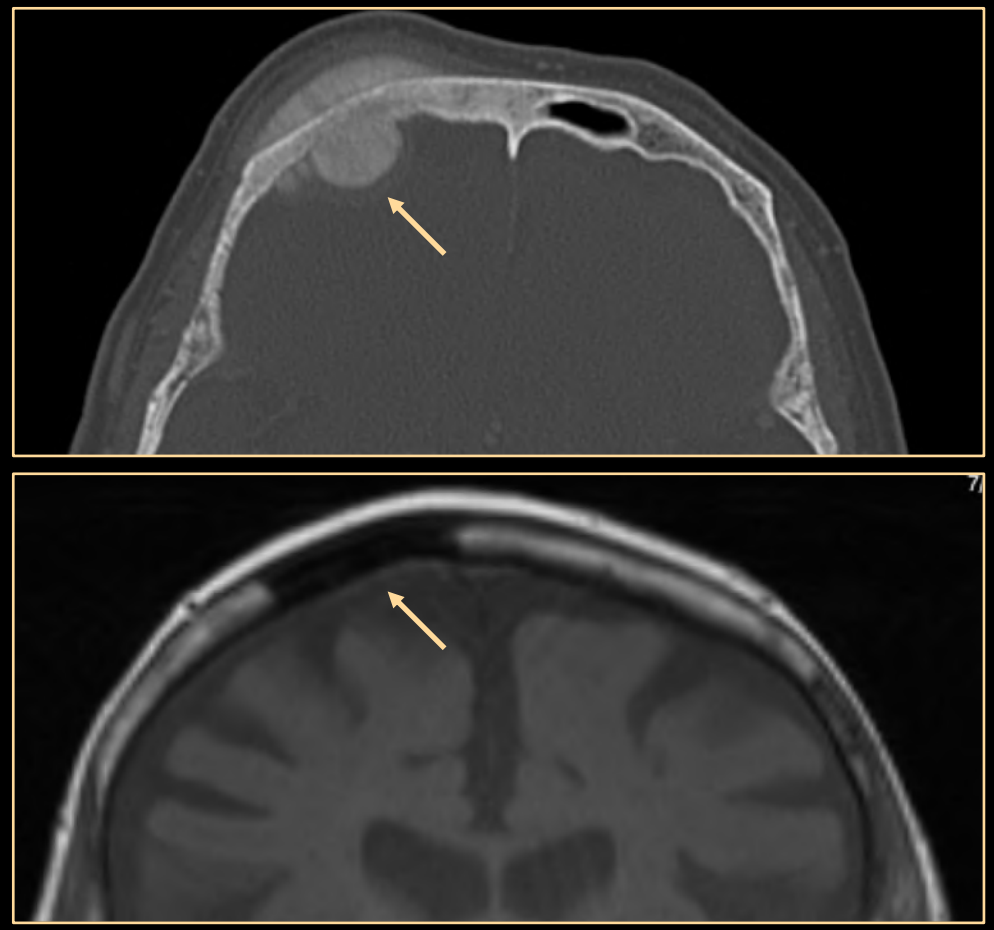
- Metastases: Lytic
- Most common malignant bone tumor
- Age: 5th decade
- Most common primary
  - **Lytic**
    - Breast > Lung (multiple)
    - Renal > Thyroid (solitary)
- Imaging
  - CT: soft tissue mass w/ bone lysis
  - MRI: T1 iso- or hypointense
  - Enhancement: homogenous, heterogenous or ring



Metastatic Breast cancer: A lytic lesion in the frontal bone (arrow) with intracranial extension and cerebral edema (arrow).

PART 3: The Unusual **Sclerotic** calvarial lesions

- Metastases: Sclerotic
- Age: 6-7th decade
- Most common primary
  - **Sclerotic**: prostate
- Imaging
  - CT: expansile sclerotic lesion
  - MRI: T1- and T2-hypointense
  - Enhancement: enhancement or peripheral rim enhancement



Metastatic prostate cancer: Sclerotic skull lesions are hyperdense on CT and markedly hypointense on T1-WI.

PART 3: The Unusual Sclerotic calvarial lesions

- Paget's Disease of Bone
- Osteitis deformans
- Abnormal bone turnover
- Age: 2% over 55y
- Location: pelvis > femur > skull
- Asymptomatic, bone pain
- Imaging: three consecutive phases
    1. Lytic phase
    2. Mixed phase
    3. Sclerotic phase

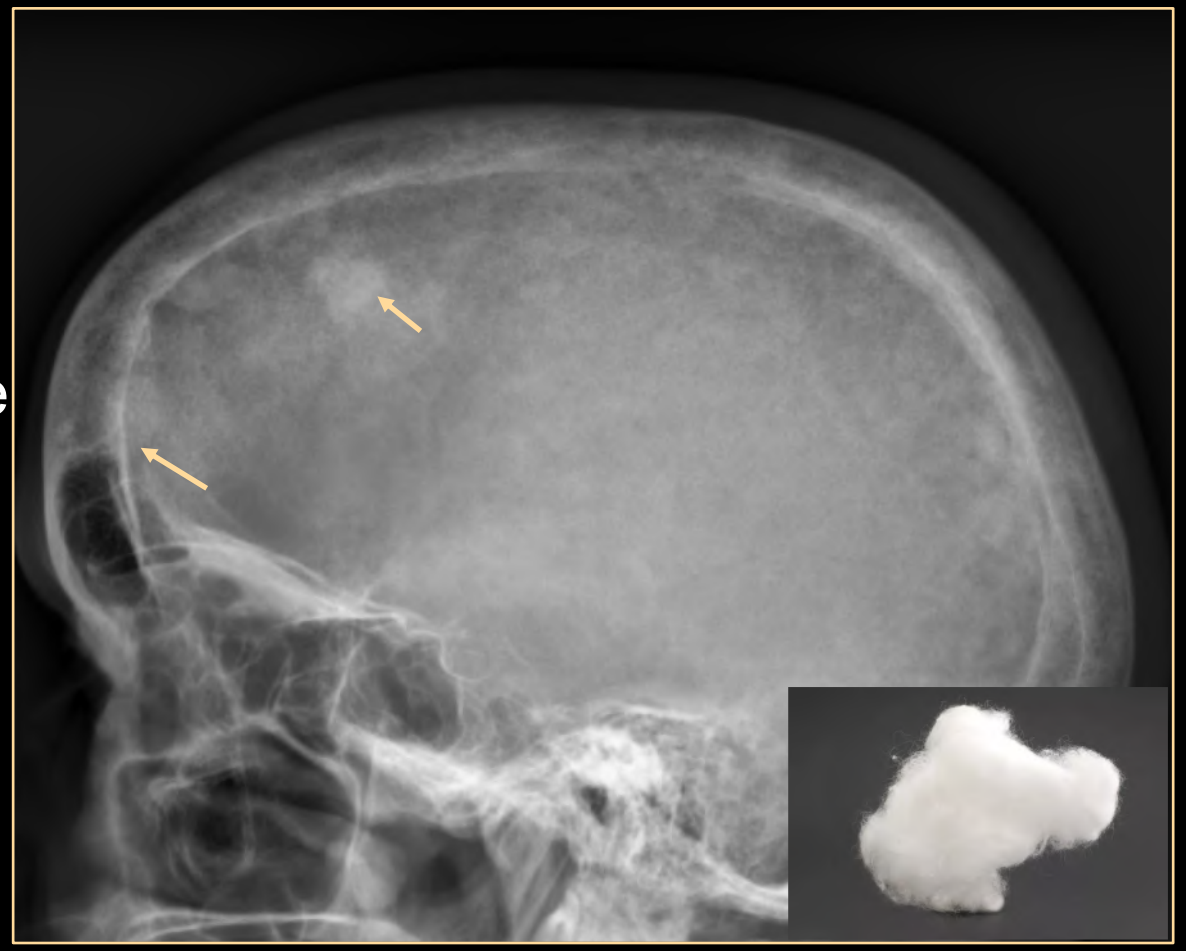
PART 3: The Unusual Sclerotic calvarial lesions

- Paget's Disease of Bone
- Lytic phase: bone resorption
  - Osteoclastic overactivity
  - Plain film/CT
    Focal sharply delineated lucent zone
    '*Osteoporosis circumscripta*'
  - MRI
    T1: lower signal than bone, iso to muscle
    T2: high signal
    Gd+: enhancement due to hypervascularity
  - Scintigraphy
    Increased uptake

A patient with a focal osteoporotic lesions (arrows). Note the sharp border of the frontal bone lesion illustrating 'osteoporosis circumscripta' (arrow).

PART 3: The Unusual Sclerotic calvarial lesions

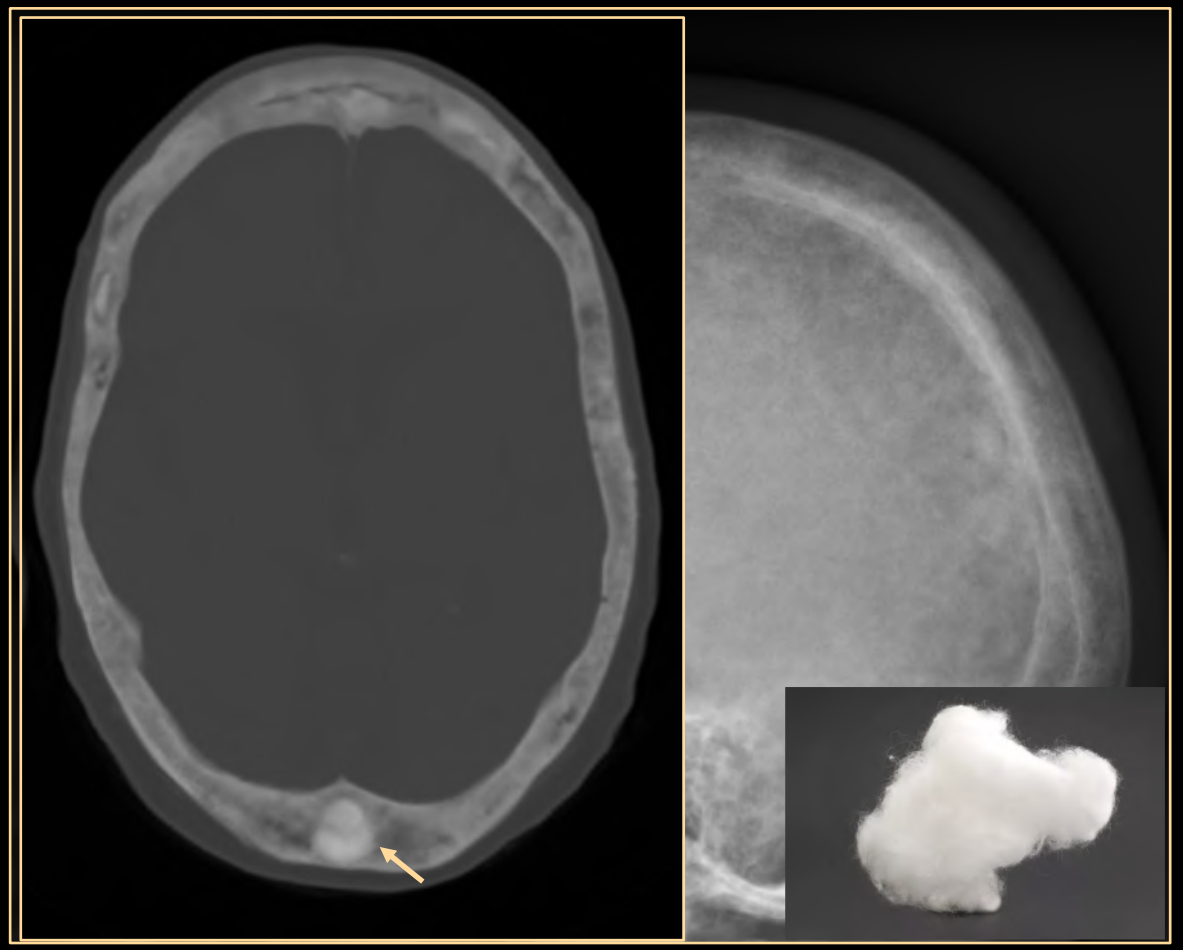
- Paget's Disease of Bone
- Mixed phase: bone formation
  - Osteoclastic overactivity
  - Plain film/CT
    Focal nodular areas of thick bone
    '*Cotton wool*'
    Cortical thickening
    Coarse trabecular pattern
  - MRI
    Preserved fatty marrow signal



Lateral radiography of the skull depicts a typical 'cotton wool' appearance of Paget's Disease.

PART 3: The Unusual Sclerotic calvarial lesions

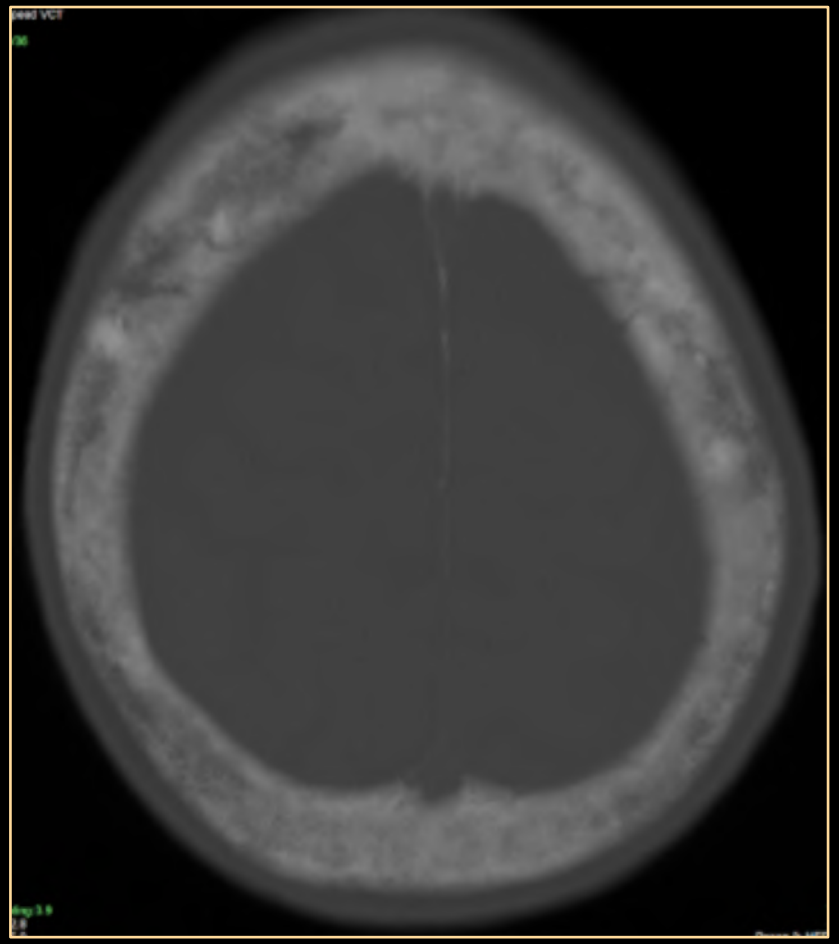
- Paget's Disease of Bone
- Mixed phase: bone formation
  - Osteoclastic overactivity
  - Plain film/CT
    Focal nodular areas of thickened '*Cotton wool*'
    Cortical thickening
    Coarse trabecular pattern
  - MRI
    Preserved fatty marrow signal



Lateral radiography of the skull depicts a typical 'cotton wool' appearance of Paget's Disease. CT correlation in a different patient (arrow).

PART 3: The Unusual Sclerotic calvarial lesions

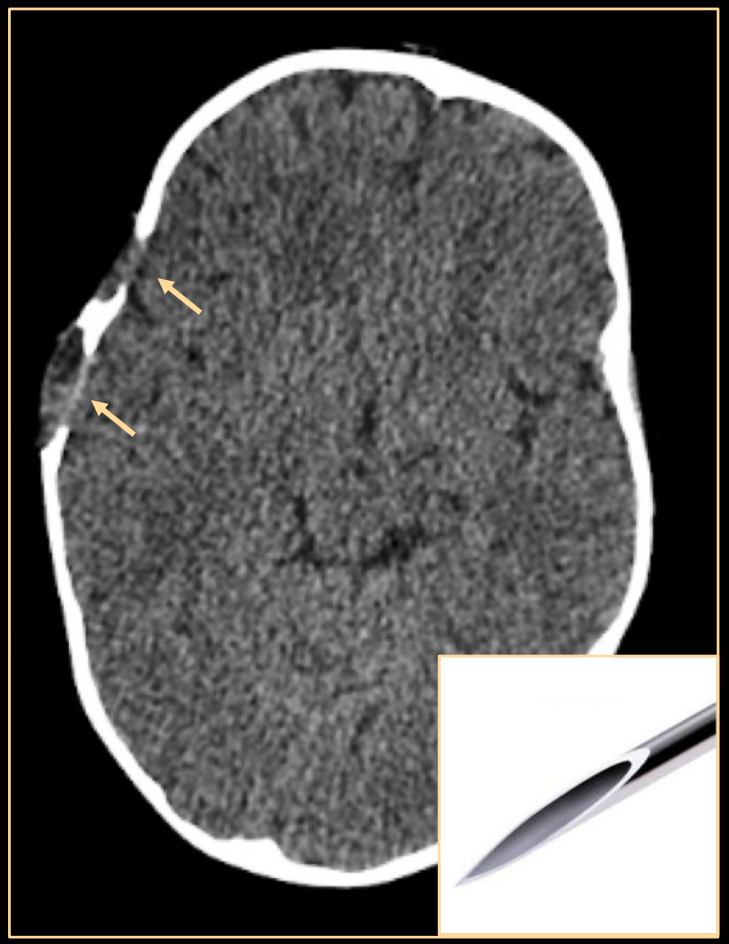
- Paget's Disease of Bone
- Sclerotic phase: mineral deposition
  - Plain film/CT
    Bone thickening and sclerosis
  - MRI
    Hypointense signal on all sequences
  - Scintigraphy
    False negative, no uptake



CT in the late phase shows more sclerotic appearance of the skull.

PART 3: The Unusual Lytic calvarial lesions

- Eosinophilic granuloma
- Unifocal Langerhans Cell Histiocytosis
- Age: young (boys)
- Location: skull affected in 50%
- Symptoms: focal pain, swelling
- Imaging
  - Plain film: punched out lesions
  - CT: *'Beveled edges'*
  - MRI:
    - T1: hypo – Isointense
    - T2: slightly hyperintense
    - Gd+: enhancement



CT depicts two lesions with larger osteolysis of the external table as compared to the internal table, creating the 'beveled edge' appearance. Beveled needle for comparison.

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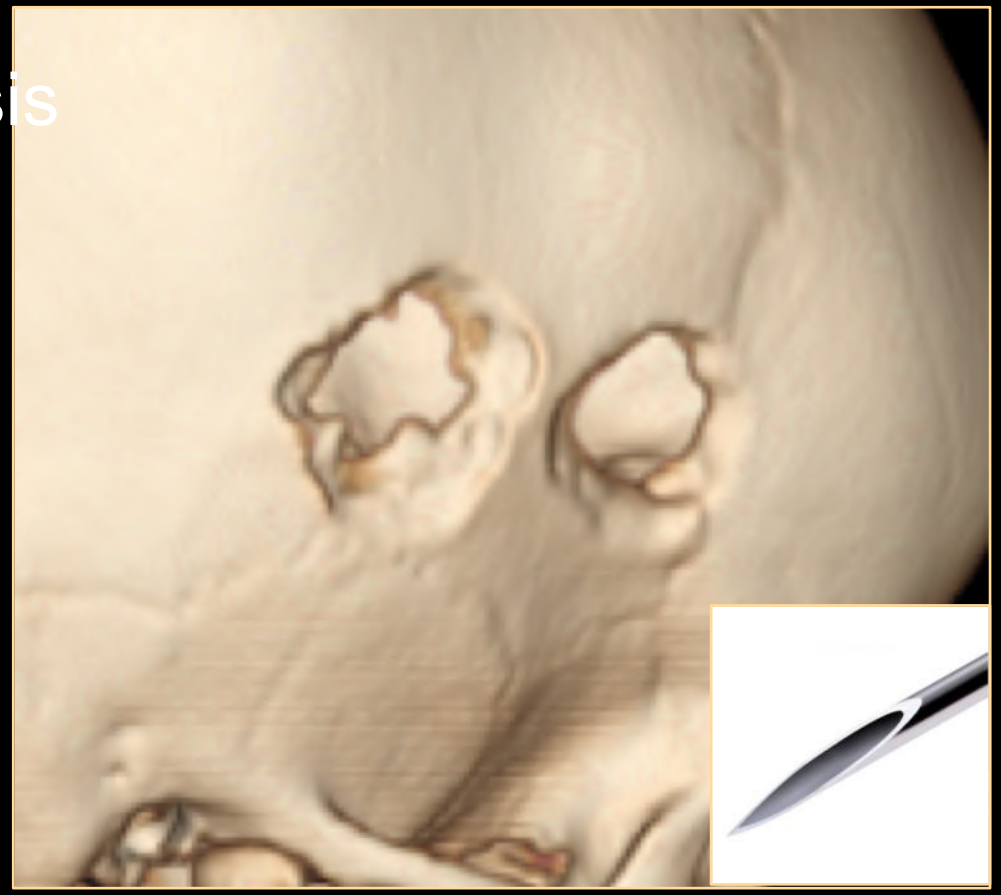
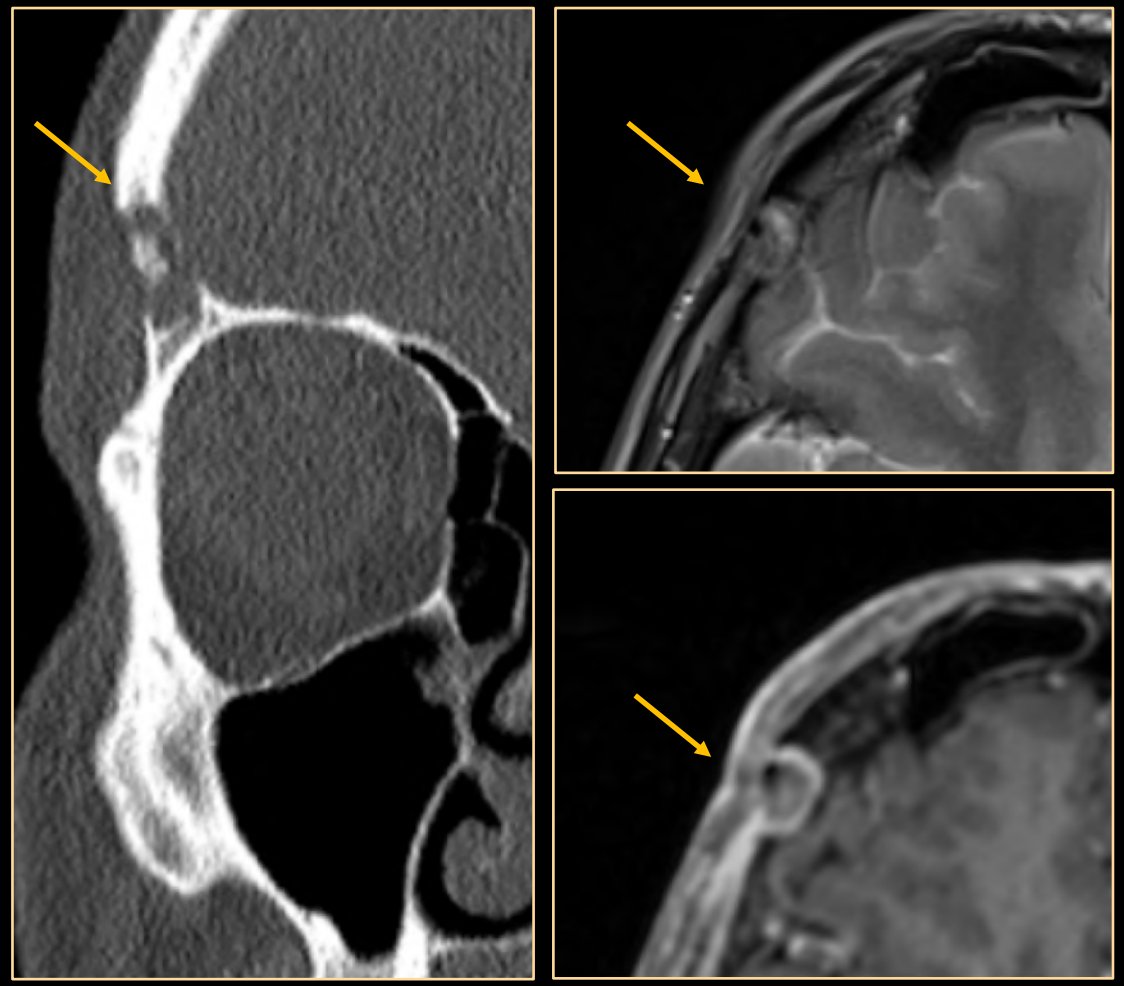


CT depicts two lesions with larger osteolysis of the external table as compared to the internal table, creating the 'beveled edge' appearance.

PART 3: The Unusual Lytic calvarial lesions

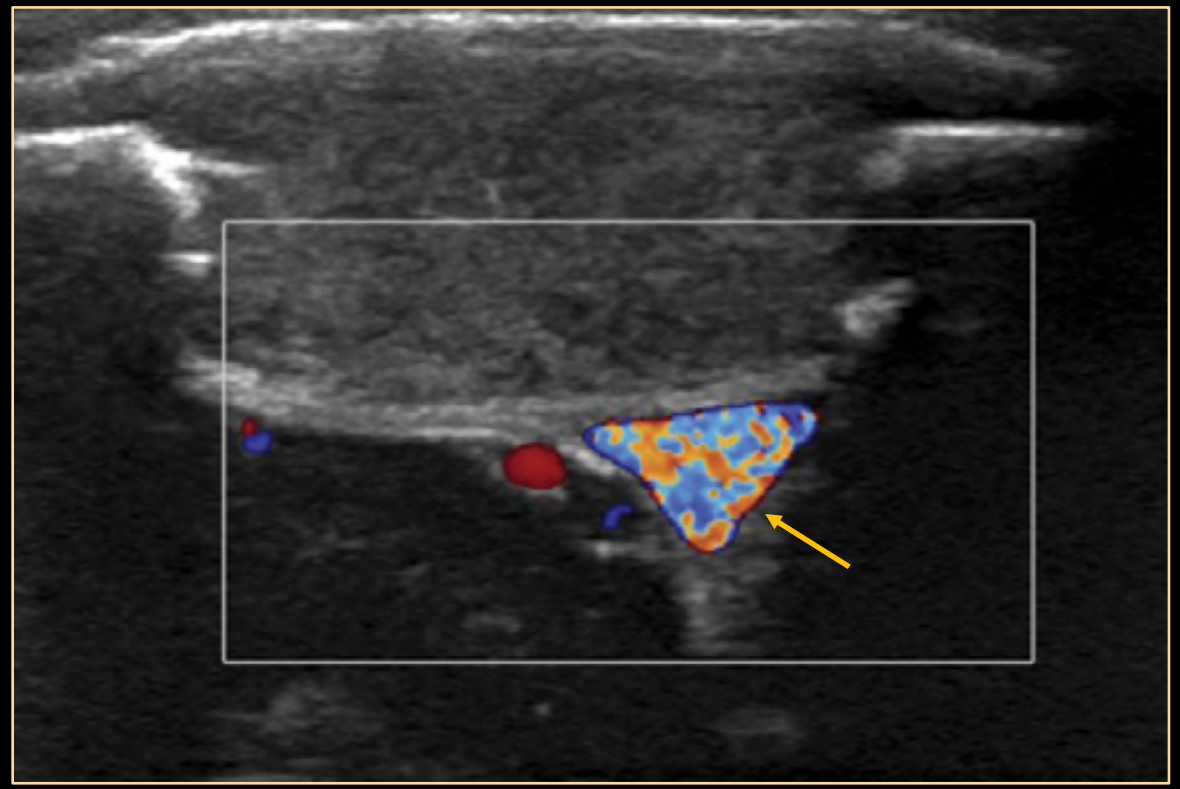
- Eosinophilic granuloma
- Age: young (boys)
- Skull affected in 50%
- Focal pain, swelling
- Imaging:
  - Plain film: punched-out lesions
  - CT: '*Button sequestrum*'
  - MRI:
    - T1: hypo – Isointense
    - T2: slightly hyperintense
    - C+: enhancement



Another typical appearance is the 'button seaquestrum' sign, where a fragment of bone is surrounded by osteolysis (arrows).

PART 3: The Unusual Lytic calvarial lesions

- Eosinophilic granuloma
- Most common: young boys
- Skull affected in 50%
- Focal pain, swelling
- Imaging
  - Plain film: punched out lesions
  - CT: ‘Beveled edges’
  - MRI
  - Ultrasound: evaluating soft tissue component



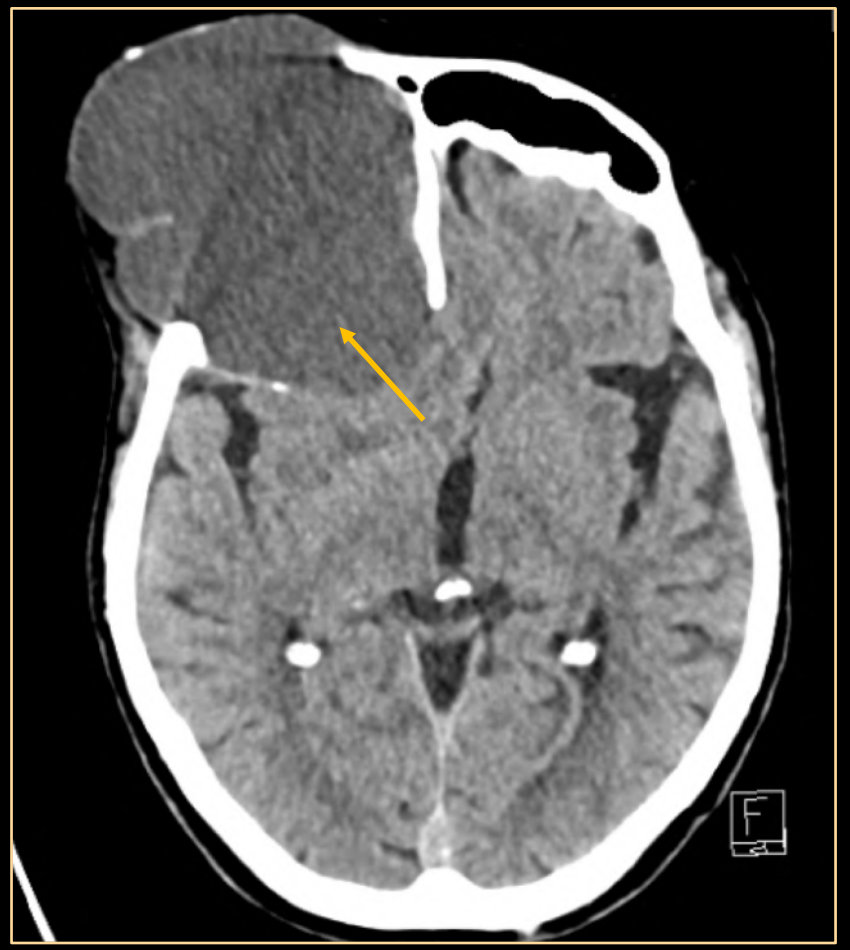
US shows a hypoechoic lesion within the skull. Note the superior sagittal sinus (arrow). Ref: F. Vanhoenacker F. J. Ultrason 2018.

PART 3: The Unusual Lytic calvarial lesions

- Epidermoid cyst
- Cholesterol and keratin
- Age: 20-50y
- Location: frontal & parietal bone
- CT
  - Intra-diploic cystic lytic lesion
  - Smooth sclerotic lesion
  - Bone remodelling
- MRI
  - T1 & T2: fluid signal
  - DWI : restricted diffusion
  - Gd+ : no or discrete peripheral enhancement

PART 3: The Unusual Lytic calvarial lesions

- Mucocoele
- Benign epithelial lined cyst
- Giant mucocoele causes erosion of bone
- Location: 90% frontal & ethmoid sinus
- Imaging:
  - CT: hypodense content + erosion of bone
  - MRI
    - T1: variable depending on content: protein = high T1-signal
    - T2: always high signal
    - DWI: no restricted diffusion
    - Gd+: peripheral, rim enhancement



CT shows a large hypodense mass with frontal bone erosion a nd extra- and intracranial extension. Ref: F.Bosmans JBSR 2020.

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- Benign epithelial lined cyst
- Giant mucocoele causes erosion of bone
- Location: 90% frontal & ethmoid sinus
- Imaging:
  - CT: hypodense content + erosion of bone
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    - T1: variable depending on content: protein = High T1-signal
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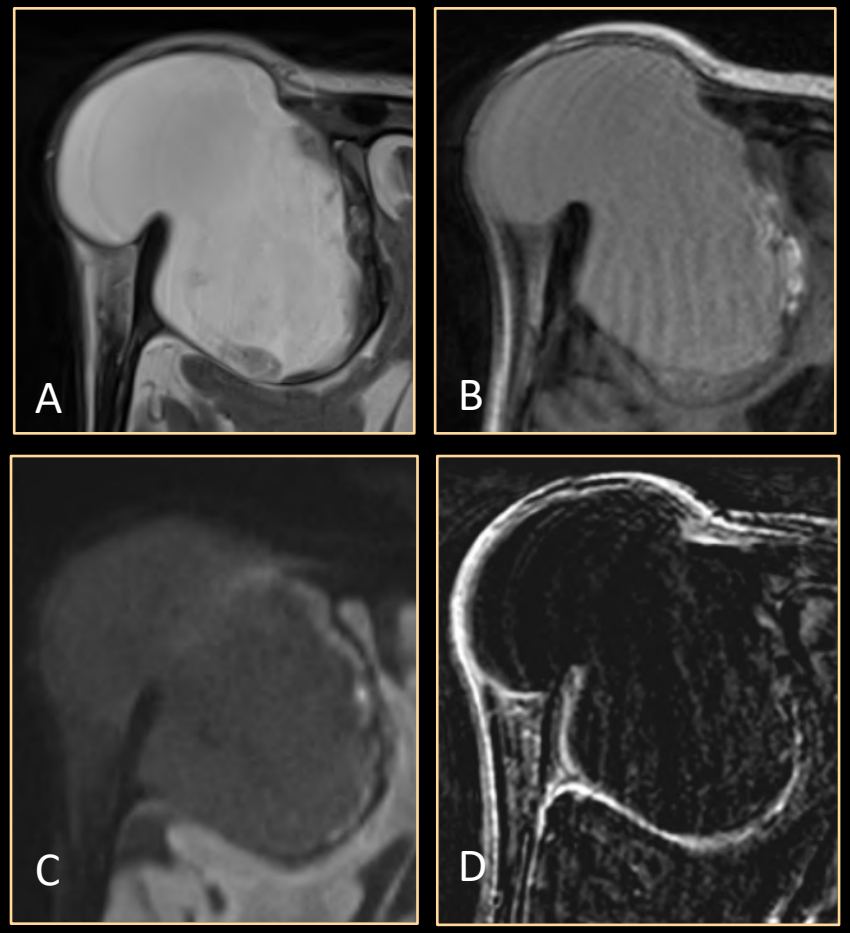
    - DWI: no restricted diffusion
    - Gd+: periferal, rim enhancement



MRI shows: (A) high T2-signal; (B) moderately high T1-signal; (C) no restricted diffusion; (D) faint rim enhancement. Ref: F.Bosmans JBSR 2020.

Take Home Messages

Calvarial Pseudo-Lesions	Usual Sclerotic Calvarial Lesions	Usual Lytic Calvarial Lesion	Unusual Sclerotic Calvarial Lesions	Unusual Lytic Calvarial Lesions
Arachnoid Granulations	Osteoma	Metastases	Paget's disease	Eosinophilic granuloma
Venous lacunae	Meningioma-en-plaque	Multiple Myeloma	Sclerotic metastases	Epidermoid cyst
Hyperostosis Frontalis Interna Hyperostosis cranii Ex Vacuo	Fibrous dysplasia	Intra-osseous hemangioma		Giant mucocoele

Take Home Messages

- Age: Young: EG - FD Old: M+, Paget
- Location: Sutures: MEP Paranasal, sphenoid: FD
- Symptoms: Pain: EG Painless: Most other
- Number: Solitary: MEP / IOH Multiple: M+ / EG

- Specific imaging features:
  - Cotton wool = Paget
  - Expansile ground glass lesion = Fibrous Dysplasia
  - Beveled edges, punched out lesions = Eosinophilic Granuloma
  - Bunch of grapes = Venous malformation
  - Cystic bone lesion with restricted diffusion = Epidermoid cyst

Suggested literature

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5. Gomez CK, Schiffman SR, Bhatt AA. Radiological review of skull lesions. Insights Imaging [Internet]. 2018 Oct [cited 2019 Apr 18];9(5):857–82.
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7. Kushchayeva YS, Kushchayev S V, Glushko TY, Tella SH, Teytelboym OM, Collins MT, et al. Fibrous dysplasia for radiologists: beyond ground glass bone matrix. Insights Imaging [Internet]. 2018 Dec [cited 2019 Apr 13];9(6):1035–56.
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